26. The method of claim 24, wherein said inert component comprises helium.

27. The method of claim 19, wherein a ratio of said oxygen-containing component to said silicon-containing component is below approximately 1.2.

28. The method of claim 19, wherein a ratio of said oxygen-containing component to said silicon-containing component is between about 1.0 and about 1.2.

29. The method of claim 19, wherein said film is deposited over said gaps at an etch-to-deposition ratio between about 0.0 and about -0.05.

30. A method for filling gaps during integrated circuit fabrication, comprising:

providing a gas mixture comprised of oxygen-containing and silicon-containing components, said gas mixture having a ratio of said oxygen-containing component to said silicon-containing component below about 1.3; and

filling said gaps by using said gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching.

REMARKS

Claims 1-30 are pending in the Application. Claim 1 has been amended. The Specification has been amended. No new matter has been added. The rejections of the claims are respectfully traversed in light of the amendments and following remarks, and reconsideration is requested.

Objection Under 35 U.S.C. § 132

The Examiner objected to the amendment filed August 20, 2002 as introducing new matter into the disclosure. The Examiner wrote in part that "and no gas flow change as compared to the [BUC] process" and "and the BUC-deposited film refractive index is about 1.46" are not supported by the original disclosure.

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Support for a BUC-deposited film refractive index is found in the Specification as filed on page 7, lines 21-24; page 9, lines 14-16; and page 15, Claim 16.

However, the above-quoted portions have been deleted from the Specification, thus obviating the Examiner's objection under 35 U.S.C. § 132

Rejection Under 35 U.S.C. § 112

Claims 1-30 are rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor, at the time the application was filed, had possession of the claimed invention.

In particular, the Examiner states in part that there does not appear to be a written description of the claim limitation "and no gas flow change as compared to the [BUC] process" and "and the BUC-deposited film refractive index is about 1.46" in the application as filed.

The above-quoted portions are **NOT** claim limitations but have been deleted from the Specification. Accordingly, Applicant respectfully requests withdrawal of the rejection of Claims 1-30 under 35 U.S.C. § 112, first paragraph.

Claims 1-29 are rejected under 35 U.S.C. § 112, second paragraph as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention.

In particular, the Examiner writes in part:

> The term "substantially the minimum necessary" and "providing a minimum flow rate" in claims 1 and 19, respectively, is a relative term which renders the claim indefinite. The term "minimum" is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

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The term "minimum" is defined in terms of the minimum ratio or minimum flow rate necessary to form a film having a desired refractive index such as 1.46. Once the desired refractive index of the film and a desired flow rate of the silicon-containing component are

selected, a minimum of the ratio of the components or a minimum flow rate of a component can be determined in order to form a film having the desired refractive index.

The Specification as filed provides a standard for ascertaining a minimum on page 7, line 8 - page 8, line 2; and on page 10, line 19 - page 11, line 2. The process involves using a "minimum flow of oxygen required to form a standard dielectric layer with a selected refractive index, for example 1.46, . . . for a given silane flow." (Specification, page 7, lines 22-27). "Advantageously, the reduced flow rate or concentration of oxygen required for a selected flow rate or concentration of silane reduces the main sputtering component." (Specification, page 7, lines 31-33). Accordingly, Applicant respectfully requests withdrawal of the rejection of Claims 1-29 under 35 U.S.C. § 112, second paragraph.

Claims 1-29 are rejected under 35 U.S.C. § 112, first paragraph, for containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

In particular, the Examiner writes in part:

> The deposition under UBUC means no etch, which means the amount of the SiO2 formed on the wafer will stay there.
>
> The deposition under BUC means a portion of the deposited SiO2 will be etched away.
>
> Therefore, the deposition rate of UBUC is <u>always larger</u> than (>) the deposition rate of BUC.
>
> . . .
>
> **Where [does] the negative E/D [come] from?**

"Table 1 . . . provides process parameter ranges . . . to form a silicon dioxide layer with a refractive index of 1.46." (Applicant's Specification as filed, page 9, lines 7-16). "UBUC is the deposition rate of the process with no wafer bias or clamping (unbiased, unclamped) . . . E/D ratios from about 0.0 to about -0.05 have been achieved for void-free gap filling, <u>where the UBUC-deposited film refractive index ranges from about 1.5 to about 1.6</u>." (Applicant's Specification as amended, paragraph beginning on page 8, line 3). When the deposition rate of the process is measured with no wafer bias or clamping and no gas flow change (e.g., no increased O_2 levels), the UBUC-deposited film refractive index changes as compared to the BUC-deposited film refractive index. The deposition rate of UBUC is larger

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than the deposition rate of BUC for the same film having the same refractive index but is NOT always larger for different films having different refractive indices. Thus, under some conditions for low deposition rates and high aspect ratio gaps, the deposition rate with bias (BUC) may be larger than the deposition rate without bias (UBUC) because the films being deposited in the two cases are of different composition (more or less silicon-richness), and therefore the E/D ratio, as defined by Applicant, may be negative. Accordingly, Applicant respectfully requests withdrawal of the rejection of Claims 1-29 under 35 U.S.C. § 112, first paragraph.

Rejection Under 35 U.S.C. § 102(b) or In the Alternative Under 35 U.S.C. § 103(a)

Claims 1-13, 15-28, and 30 stand rejected as being anticipated by, or, in the alternative under 35 U.S.C. § 103(a) as being obvious over Papasouliotis et al. (U.S. Patent No. 6,030,881). Applicant respectfully traverses these rejections.

In rejecting the claims, the Examiner states in part with respect to Claim 1:

> Papasouliotis teaches [a] method for filling a gap during integrated circuit fabrication as claimed including . . .
>
> performing an HDP-CVD process using the gas mixture to fill the gap with a dielectric (525), wherein the ratio of the oxygen containing component to the silicon-containing component is substantially the minimum necessary to form the dielectric. (See Figs. 5A-C).
>
> Note that, the ratio of the oxygen-containing component [to the silicon-containing component] in the gas mixture of Papasouliotis appears to be substantially the minimum necessary to form the dielectric. (emphasis added).

The Examiner states in part with respect to Claim 19:

> Papasouliotis teaches [a] method for filling a gap during integrated circuit fabrication as claimed including . . .
>
> providing a minimum flow rate of oxygen-containing component to allow formation of a film having a refractive index of about 1.46; and
>
> filling the gap by depositing the film (525) over the gaps (510) by using the gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching (HDP-CVD). (See Figs. 5A-C).

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> Note that, the flow rate of oxygen-containing component of Papasouliotis appears to be a minimum to allow the formation of a dielectric film.
>
> Further, since the dielectric of Papasouliotis is SiO_2, thus, it meets the claimed refractive index limitation.

The Examiner states in part with respect to Claim 30:

> Papasouliotis teaches [a] method for filling a gap during integrated circuit fabrication as claimed including . . .
>
> providing a gas mixture . . . having a ratio of oxygen-containing component to silicon-containing component [below about 1.3]; and
>
> filling the gaps by using the gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching (HDP-CVD). (See Figs. 5A-C).
>
> Note that, the ratio of the oxygen containing component to silicon-containing component in the gas mixture of Papasouliotis appears to include the claimed ratio.
>
> Further, within purview of one having ordinary skill in the art, it would have been obvious to determine the optimum ratio of the oxygen containing component to silicon-containing component in the gas mixture in the formation of the dielectric layer. See In re Aller, Lacey and Hall (10 USPQ 233-237) "It is not inventive to discover optimum or workable ranges by routine experimentation."

Applicant notes the following feature of his invention. Specifically, Applicant provides a method of filling high aspect ratio gaps without the void formations typical of the prior art using a single gas mixture with a minimized ratio of the oxygen-containing component to the silicon-containing component or a minimized flow rate of the oxygen-containing component to form a film of a selected refractive index.

Papasouliotis stands in sharp contrast to such a process. Papasouliotis discloses deposition/etch cycling using different gas mixtures having different etch/dep ratios to fill the gap. In particular, Papasouliotis discloses "multiple sequential deposition and etch steps of different etch rate-to-deposition rate (etch/dep) ratios to fill high aspect ratio gaps" (Papasouliotis, col. 5, lines 19-21). The first step is a deposition step in which "[c]usps 530 begin to form at the corners of circuit elements 520 as SiO_2 layer 525 fills gap 510, as shown in FIG. 5A. Before cusps 530 close the entry to gap 510, the deposition step is stopped." (Papasouliotis, col. 5, lines 58-61). The "deposition/etching cycle is repeated as many times as necessary until the resulting gap can be filled by a conventional HDP deposition step (FIG.

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5A) without void formation, as shown in FIG. 5C." (Papasouliotis, col. 6, lines 9-12). Accordingly, Papasouliotis discloses a conventional HDP deposition step in which voids will be formed if etch cycling with a different gas mixture is not performed.

Applicants could find no mention in Papasouliotis of a ratio of the oxygen-containing component to the silicon-containing component or the refractive index of a dielectric.

In particular, Applicant could find no teaching or suggestion in Papasouliotis for performing an HDP CVD process using a single gas mixture to fill a gap with a dielectric at a selected refractive index, wherein the ratio of an oxygen-containing component to a silicon-containing component is substantially the minimum necessary to form the dielectric at the selected refractive index. Applicant could find no teaching or suggestion in Papasouliotis of the selecting of a flow rate of the silicon-containing component and the providing of a minimum flow rate of the oxygen-containing component to allow formation of a film having a refractive index of about 1.46. Applicant could find no teaching or suggestion in Papasouliotis of a single gas mixture having a ratio of an oxygen-containing component to a silicon-containing component below about 1.3 and using the single gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching to fill gaps.

Applicant further contends that it would not have been obvious to determine the optimum ratio of the oxygen-containing component to silicon-containing component in the gas mixture given that Papasouliotis does not mention the ratio, optimizing composition, or refractive index. Instead, Papasouliotis discusses deposition/etch cycling and "the need for optimizing the duration of deposition steps." (Papasouliotis, col.6, ll.66-67). Optimizing duration of deposition steps involved in cycling can even teach away from an optimum composition of reactants for a single duration step, which may not be efficient or optimal in terms of step duration.

In contrast, amended Claim 1 recites a "method for filling a gap during integrated circuit fabrication, comprising . . . performing an HDP-CVD process using the gas mixture to fill the gap with a dielectric having a selected refractive index, wherein the ratio of the oxygen-containing component to the silicon-containing component is substantially the minimum necessary to form the dielectric having the selected refractive index." Therefore, because Papasouliotis does not disclose or suggest all the limitations of Claim 1, Claim 1 is patentable over Papasouliotis.

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Similarly, Claim 19 recites a "method for filling gaps during integrated circuit fabrication, comprising . . . providing a minimum flow rate of said oxygen-containing component to allow formation of a film having a refractive index of about 1.46; and filling said gaps by depositing said film over said gaps using said gas mixture." Therefore, because Papasouliotis does not disclose or suggest all the limitations of Claim 19, Claim 19 is patentable over Papasouliotis.

Similarly, Claim 30 recites a "method for filling gaps during integrated circuit fabrication, comprising . . . providing a gas mixture . . . having a ratio of said oxygen-containing component to said silicon-containing component below about 1.3; and filling said gaps by using said gas mixture for simultaneous high density plasma chemical vapor deposition and sputter etching. Therefore, because Papasouliotis does not disclose or suggest all the limitations of Claim 30, Claim 30 is patentable over Papasouliotis.

Claims 2-13 and 15-18 are dependent on Claim 1 and contain additional limitations that further distinguish them from the cited reference. Therefore, Claims 2-13 and 15-18 are allowable for at least the same reasons provided above for Claim 1. Claims 20-28 are dependent on Claim 19 and contain additional limitations that further distinguish them from the cited reference. Therefore, Claims 20-28 are allowable for at least the same reasons provided above for Claim 19. For at least these reasons, Applicant respectfully requests allowance of Claims 1-13, 15-28, and 30.

Rejection Under 35 U.S.C. § 103(a)

Claims 14 and 29 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Papasouliotis. Claims 14 and 29 are dependent on Claims 1 and 19, respectively, and contain additional limitations that further distinguish them from the cited reference. Therefore, Claims 14 and 29 are allowable for at least the same reasons provided above for Claims 1 and 19, respectively.

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CONCLUSION

For the above reasons, pending Claims 1-30 are believed to be in condition for allowance and allowance of the Application is hereby solicited. If the Examiner should have any questions or concerns, the Examiner is hereby requested to telephone Applicant's Attorney at (949) 752-7040.

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Respectfully submitted,

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ATTACHMENT A

This response amends the specification as follows. In the following paragraph, insertions are underlined and deletions are enclosed in brackets.

The paragraph on page 8, line 3 through line 22, is amended as follows:

In addition to a reduced oxygen to silane ratio, the method of the present invention allows for low etch-to-deposition (E/D) ratios, corresponding to greater gap-fill capability. An E/D ratio is defined by the equation:

E/D = (UBUC-BUC)/UBUC

where UBUC is the deposition rate of the process with no wafer bias or clamping (unbiased, unclamped) [and no gas flow change as compared to the BUC process], and BUC is the deposition rate of the process with wafer bias and no clamping (biased, unclamped). In one embodiment of the present invention, as the minimized oxygen to silane ratio is used to minimize the oxygen flow rate and to reduce the silane flow rate for depositing a dielectric layer, E/D ratios have also been reduced. Reduced E/D ratios correspond to the overall sputtering rate decreasing, and the aspect ratio gapfill capability increasing. For example, E/D ratios from about 0.0 to about -0.05 have been achieved for void-free gap filling, where the UBUC-deposited film refractive index ranges from about 1.5 to about 1.6 [and the BUC-deposited film refractive index is about 1.46].

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ATTACHMENT B

The amended claims with markings showing the changes are as follows:

1. (Twice Amended) A method for filling a gap during integrated circuit fabrication, comprising:

providing a gas mixture comprised of a silicon-containing component and an oxygen-containing component;

selecting a flow rate of said silicon-containing component; and

performing an HDP-CVD process using the gas mixture to fill the gap with a dielectric having a selected refractive index, wherein the ratio of the oxygen-containing component to the silicon-containing component is substantially the minimum necessary to form the dielectric having the selected refractive index.

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